Sir Joseph Banks
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RESULT OF CALCULATIONS OF THE OBSERVATIONS MADE AT VARIOUS PLACES OF THE ECLIPSE OF THE SUN, WHICH HAPPENED ON JUNE 3, 1788.

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RESULT OF CALCULATIONS, &c.

Read at the ROYAL SOCIETY, January 15, 1789.

TO DR. MASKELYNE.

SIR,

THE ſatisfaction I had in obſerving the eclipſe of the ſun on the third of June laſt, with you and M. D'ARQUIER, at Greenwich, induces me to give you an account of the uſe made of the obſervations, and the conſequences I have drawn from them. The obſervations which I have collected concerning the ſame eclipſe, and which were made in other places, contribute to the extenſiveneſs of my calculations, and to determine the poſition of certain places, which had not been before accurately determined, as that of Dublin, that of Mitau in Courland, and Perinaldo in Italy. The longitudes of all the other places muſt be referred to that of the Royal Obſervatory at Greenwich, as being the firſt in Europe, and becauſe the obſervations which you have made in it, are by far more accurate than any others made elſewhere.

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The reſult of the obſervation at Greenwich is confirmed in the moſt ſatisfactory manner by the obſervations of Oxford and Loampit-Hill, which Dr. Hornsby and Mr. Aubert have done me the honour to communicate to me. Theſe three obſervations perfectly agree in the latitude of the moon; whence it follows, that the duration of the eclipſe was juſtly obſerved. And whereas the difference of longitude for Oxford, as determined by theſe obſervations, is only one ſecond, and that of Loampit-Hill only two ſeconds, different from that which had been determined by means of the beſt time-keepers and other moſt exact obſervations, it follows, that theſe three obſervations may be conſidered as a ſingle one, having a treble degree of accuracy. In effect, if the moment of conjunction found for Oxford and Loampit-Hill be reduced to the meridian of Greenwich, by adding to the latter 5″,4, and to the former 5′ 0″, and a mean be taken, it will appear, that this mean differs only by 0,6 of a ſecond from the conjunction deduced from the obſervation made at Greenwich only. This alſo clearly proves, that the eclipſes of the ſun, when accurately obſerved, give nearly the ſame exactneſs as the occultations of the ſtars, which from their nature are conſidered as the moſt exact.

The obſervation made at Dublin deſerves our greateſt attention, particularly ſince the eſtabliſhment of a very excellent obſervatory there. Dr. Ussher confeſſes, that the longitude of that city has not been exactly determined (ſee the Tranſactions of the Royal Iriſh Academy for the year 1787, p. 86.). He ſuppoſes the longitude of Dublin to be 24′ 58″ W. which he determined by means of a time-keeper, which Mr. Arnold happened to take with him to that city; whereas I find it to be 25′ 13″,4. This my determination I believe not to leave the uncertainty of two ſeconds, becauſe the latitude of the moon deduced from the obſervation is the ſame with that of Greenwich.

The obſervation of Mitau is likewiſe very intereſting; it ſhews the ſituation of a diſtant country, where no obſervation had been made before M. **Beitler** eſtabliſhed an obſervatory there. The obſervation of this able aſtronomer is of ſuch correctneſs, that it furniſhes the ſame latitude of the moon as the preceding ones; conſequently the difference of the meridians, which I thence deduce, may be conſidered to be as exact as that of Dublin. The difference is 1 h. 34′ 54″ E, which becomes of the greater importance to geography, becauſe from Pomerania to Peterſburg no one point had been accurately determined before.

The poſition of Berlin has been already determined by means of ſome eclipſes; but the reſults do not agree. The difference of 53′ 32″, which I have deduced, not only agrees exactly with that mentioned in Vol. IV. of M. **de la Lande**'s Aſtronomy, and which this famous aſtronomer had deduced from the occultation of Antares obſerved by himſelf in the year 1749; but it alſo comes ſo near to the longitude mentioned by Meſſ. **Lexell** and **Bernoulli**, in the Ephemeris of Berlin, as not to differ by more than two ſeconds.

The obſervation of Vienna gives for the difference of the meridians 1 h. 5′ 31″. Though this determination differs but 1″ from that found in the Almanack of Milan, and in the *Requiſite Tables*, yet the obſervations of the two phaſes had not been very accurately made.

Perinaldo in Italy is a place whoſe poſition has not been as yet well determined. The tables requiſite for the Nautical Ephemeris lay down this place at 30′ 40″ to the Eaſt of Greenwich; ſome place it at 30′ 20″. The obſervation made by

M. MARALDI, nephew of the Paris Academician, which I have by me, gives 30′ 53″ E. for the difference of the meridians, and this may be conſidered as the beſt hitherto known.

The obſervations made at Milan, by the aſtronomers DE CESARIS and REGGIO, were interrupted by intervening clouds. In fact, the latitude of the moon in conjunction comes out only equal to 14′ 32″, which ſhews that the duration of the eclipſe was not properly obſerved. I have thence alſo calculated the conjunction ſeparately for the beginning and for the end of the eclipſe, and I have found out the following differences of meridians, *viz.* for the beginning 36′ 39″,6, and for the end 36′ 38″; and for the end and beginning conjointly 36′ 37″. This laſt difference comes neareſt to that mentioned in the Milan Ephemeris for the year 1789, which is 36′ 41″. The obſervation made at Bologna aſſigns 45′ 28″ E. for the difference of the meridians. But the duration of the eclipſe was not properly obſerved. However, notwithſtanding this imperfection, it may happen that the reſult determined is exact.

The two obſervations of France, *viz.* that of Viviers, and that of Rouen, give almoſt the ſame difference which I find in the Requiſite Tables; that of Rouen differing only 1″, and that of Viviers 2″. As the difference of the meridians between Paris and Rouen is known with the greateſt preciſion to be 4′ 57″ to the W. of Paris; if to this difference are added 4′ 22″,3, which is the difference I found between Rouen and Greenwich, there will reſult, for the difference of the meridians between the Obſervatory of Greenwich and Paris, 9′ 19″,3. This difference only differs by 0″,7 from that eſtabliſhed by Dr. BRADLEY, which is 9′ 20″, as adopted by yourſelf, and lately confirmed by Major-general ROY.

The obſervations of Loampit-Hill, Greenwich, and Oxford, as they ſerve for the baſis of all my calculations, I have calculated them two different ways, *viz.* by the method of parallactic angles, and by the method of the nonageſimal, and the reſults agreed together within a few tenths of a ſecond. By theſe two different methods I have alſo calculated the obſervations of Vienna, Berlin, and Viviers, in order to ſhew, that the different latitudes of the moon, given by the various obſervations, were not owing to any error in my calculations. For theſe places, in which both the beginning and the end of the eclipſe had been obſerved, I have deduced the time of conjunction from the two phaſes conjointly, which have alſo given the duration of the eclipſe, which cannot be obtained from a ſingle obſervation.

The error of the tables which reſults from the obſervation at Greenwich is + 26″ in longitude, and + 11″,5 in latitude, at 20 h. 58′ 47″,3 of apparent time, taking for the longitude of the ſun 2 s. 14° 16′ 54″,7, as I deduce from the Nautical Almanack, and that of the moon at the ſame time to be greater than the ſun by 26″, as deduced from the ſame Almanack. I ſuppoſe alſo the horary motion of the moon in the ecliptic, by taking it an half hour before and after the conjunction, to be 36′ 52″ + 0″,6 for the hour following the conjunction, and − 0″,6 for the hour preceding the conjunction; the moon's horary motion in latitude is 3′ 24″,3; the horizontal parallax of the moon *minus* that of the ſun at Greenwich, to be 60′ 14″,4 for the commencement of the eclipſe, and 60′ 16″,4 for the end; the ſun's diameter 31′ 34″,6, leſs by 3″ than that given in the Almanack, according to the correction which you have found neceſſary to be made; the moon's diameter I have ſtated as in the Almanack. In the opinion of M. DE LA LANDE, ſome correction ought to be made to the parallax and to the diameter of the moon, as well as to the diameter of the ſun; but on the one hand this would not make any alteration in the difference of the meridians which I have found; and on the other I thought proper to make uſe of thoſe elements the Nautical Almanack furniſhed me with, that being a work the moſt perfect of the kind that ever appeared, and to which all aſtronomers and navigators ought to pay the greateſt attention.

In fine, I compared the moon's longitude in conjunction deduced from the eclipſe with the new tables of the moon corrected by Mr. Mason, and found the longitude by thoſe tables to be 2 s. 14° 17′ 6″,4, and the latitude to be 15′ 1″,3. The error then of the new Tables is + 11″,7 in longitude, and + 13″,1 in latitude; but M. de la Lande having lately ſent to me from Paris the place of the ſun, calculated with the new Solar Tables (a moſt uſeful improvement which M. de Lambre has, with much ingenuity, deduced from your obſervations) I find the error in longitude to be + 27″,4, the ſun's place being 2 s. 14° 16′ 39″,0 at 20 h. 58′ 47″,3.

The following table contains the obſervations of the eclipſe, and the reſults deduced from thence. The firſt vertical column ſhews the name and place of the obſervers; the two next vertical columns contain all thoſe obſervations which have been made, in apparent time; the other columns ſhew the reſults, *viz.* the fourth column, contains the true conjunction in apparent time; the fifth column contains the longitude of the moon in conjunction, which being always the ſame, needs not to be repeated under every perpendicular column; the ſixth column contains the latitude of the moon, which, as it depends upon the manner of obſerving the two phaſes, is ſubject to ſome

ſome variety; the ſeventh or laſt column contains the difference between the various meridians and that of Greenwich.

This, Sir, in brief, is the reſult which I have been able to deduce from the various obſervations above mentioned, and which I intirely ſubmit to your judgement. If you think that it deſerves to be made public, and in that caſe would be pleaſed to preſent this Paper to the Royal Society, I ſhall eſteem myſelf extremely honoured and obliged by it.

I have the honour to be, &c.

JOSEPH PIAZZI.

Table

Table of the obſervations made at various places on the eclipſe of the ſun, which happened June 3, 1788, and of reſults deduced from the ſame.

	Beginning.	End.	Conjunction.	Longitude of the moon in conjunction.	Latitude in conjunction	Difference of meridians.
Greenwich, Dr. MASKELYNE.	h. ′ ″ 19 24 46,5	h. ′ ″ 21 1 24,0	h. ′ ″ 20 58 47,3		′ ″ 14 48,2	0
Loampit-Hill, Mr. AUBERT.	19 24 41,9	21 1 20,3	20 58 44,1		14 48,2	″ 3,2W
Oxford, Dr. HORNSBY.	19 20 36,1	20 54 40,0	20 53 46,2		14 48,7	′ ″ 5 1,1W
Dublin, Dr. USSHER.	19 5 46,5	20 27 42,1	20 33 33,9		14 48,3	25 13,4W
Mittau, M. BEITLER.	21 20 15,0	23 8 52,0	22 33 41,5		14 48,7	h. ′ ″ 1 34 54 2E
Berlin, M. BODE.	20 23 9,0	22 14 32,0	21 52 20,3		14 44,2	0 53 33E
Vienna, M. TRIESNEKER.	20 25 49,0	22 32 40,0	22 4 18,8	S. ° ′ ″ 2 14 16 54,7	14 39,0	1 5 31,5E
Viviers, M. FLAUGERGUAS.	19 26 38,0	21 25 41,0	21 17 29,0		14 33,0	′ ″ 18 41,7E
Perinaldo, M. MARALDI.	19 37 50,0	*	21 29 40		*	30 53,0E
Rouen, M. DU LAGNE.	*	21 7 15,0	21 3 9,6		*	4 22,3E
Milan, Meſſ. DE CESARIS and REGGIO.	19 48 23,0	21 51 14,0	21 35 24,7		14 32,0	36 37,4E
Bologna, M MATTEUCCI.	19 55 10,5	22 3 45,5	21 44 15,3		14 31,0	45 28E
Padua, M. CHIMINELLO.	19 59 20,0	22 6 58,0	21 46 21,3		14 39,0	47 34E

POSTSCRIPT.

IN the month of February laſt, I was favoured by Count **DE BRUHL** with the obſervation of the eclipſe of the 4th of June laſt, made at Warſaw by M. **BYSTRZYSKI**; about the ſame time I alſo received of M. **DE LA LANDE** ſome other obſervations of the ſame eclipſe, *viz.* thoſe made at Prague, Marſeilles, Creſmunſter, and Bagdad in Meſopotamia, which I immediately calculated, in order to add them to the others, which Dr. **MASKELYNE** lately did me the honour of preſenting to the Royal Society.

The obſervation of Marſeilles confirms in the beſt manner the difference of meridians ſet down in the *Requiſite Tables*, differing from that only by a ſecond. The obſervation of Warſaw gives a difference ten ſeconds greater, and that of Creſmunſter fourteen ſeconds leſs; which differences ought not to ſurprize us, conſidering the obſervations upon which the longitudes of theſe two places had been eſtabliſhed; but, on the other hand, the obſervation of Prague clearly proves, that the ſituation of that town had been much leſs accurately determined than one might have expected. The time for the conjunction, which reſults from this obſervation, is the very ſame as that which is deduced by M. **GERSTNER**'s new method, deſcribed in the Berlin Ephemeris for the year 1791, p. 243. From this time of conjunction the difference of meridians comes out equal to 57′ 42″,7, *viz.* one minute and ſeventeen ſeconds leſs that that of the Requiſite Tables.

The calculation of the obſervation made at Bagdat ſeems to indicate that there is ſome miſtake with regard to the end of the eclipſe, having found, that the difference of apparent longitude

gitude at the end is 20″ greater than the ſum of the ſemidiameters of the ſun and moon, increaſed in proportion of the apparent altitude of the moon: for this reaſon I do not give the moon's latitude in conjunction. As for the time of the conjunction, I deduce it both from the two phaſes together, and from the commencement only, having previouſly corrected the moon's latitude of the error which I diſcovered in the tables, *viz.* 11″,6. The time of conjunction which reſults from the firſt calculation is 23 h. 56′ 11″; that which reſults from the ſecond 23 h. 56′ 16″: this laſt nearly agrees in the difference of meridians with the Ephemeris of Paris for the year 1789, and differs from the Requiſite Tables by 2′ 32″.

The following table repreſents, as the firſt, the obſervations and the reſults.

	Beginning.	End.	Conjunction.	Longitude.	Latitude.	Difference of meridians.
	h. ′ ″	h. ′ ″	h. ′ ″		′ ″	h. ′ ″
Warſaw, M. BYSTRZYSKI	20 56 45	22 57 33	22 22 59,3		14 44	1 24 12
Prague, M. STRNADT.	20 21 29	22 21 15	21 56 30		14 45	0 57 42,7
Marſeilles, M. BERNARD.	19 26 42	21 29 23,5	21 20 17,5		14 40	0 21 30,2
Creſmunſter, M. FIXLMILLNER.	20 15 20	22 19 50,7	21 54 59		14 23	0 56 11,7
Bagdad, M. DE BEAUCHAMP.	22 30 51	23 26 19	23 56 11		*	2 57 23,7

If it be thought neceſſary to take notice of the irradiation, and of the inflexion of light, then 6″,5 muſt be ſubtracted from the half ſum of the ſemi-diameters of the ſun and moon, which has been employed in the foregoing calculations. This correction does not alter the conjunction deduced from the two phaſes together; but it can only occaſion ſome difference with reſpect to the latitude of the moon in conjunction, and to the conjunctions deduced from one of the phaſes only. In order to aſcertain theſe differences, I firſt applied the ſaid correction to the obſervation made at Greenwich; then calculated the latitude of the moon in conjunction, which was found equal to 14′ 58″, and the error of the table was + 1″,9. This done, I again calculated all the obſervations, correcting the half ſum of the ſemi-diameters of the ſun and moon, by 6″,5, and the latitude by 1″,9. The conjuctions thus deduced from each of the phaſes ſingly conſidered, have generally agreed better with the mean conjunction than when no correction was uſed, or when there was uſed only the correction of 6″,5 for the diſtance of the centers, or of 11″,6 for the latitude.

Theſe new or corrected conjunctions will be found in the following table, in order that if any perſon entertain ſome doubt with reſpect to the mean conjunction, he may chooſe amongſt the extreme ones that which may ſeem to be the moſt proper. To theſe I have added two other obſervations of the ſame eclipſe, *viz.* one made at Abo in Finland by M. Lindquist, and the other made by M. Nahe at Lilienthal, in the dutchy of Breme, in which place M. Schroter has erected a new obſervatory.

Table of the conjunctions deduced from each of the phaſes ſingly.

	Commencement.			End.		
	h.	′	″	h.	′	″
Greenwich	20	58	47,2	20	58	47,4
Loampit-hill	20	58	44,1	20	58	44,2
Oxford	20	53	43,8	20	53	47,1
Dublin	20	33	37,6	20	33	30,2
Mittau	22	33	37,6	22	33	45,0
Milan	21	35	25,2	21	35	25,0
Marſeilles	21	20	20,4	21	20	14,3
Berlin	21	52	22,9	21	52	14,0
Prague	21	56	33,8	21	56	26,1
Vienna	22	4	24,2	22	4	13,8
Padua	21	46	25,1	21	46	17,9
Bologna	21	44	28,3	21	44	4,2
Creſmunſter	21	55	21,2	21	54	37,0
Viviers	21	17	41,2	21	17	18,4
Warſaw	22	23	1,7	22	22	55,7
Bagdat	23	56	15,3	23	56	6,5
Rouen		*		21	3	10,6
Perinaldo	21	29	40		*	
Abo	22	27	50,7	22	27	20,4
Lilienthal		*		21	34	39,1